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Effect of Five-Step Learning Cycle Model on Students' Understanding of Concepts Related To Elasticity

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ABSTRACT

The study investigated the effects of five-step (5E) learning cycle model on the students understanding of concepts related to elasticity. 100 students participated in answering questions on the concepts in physics concept test. The students' responses were analyzed in accordance with their views. Through their responses, it was found that most students held alternative conceptions of the concepts related to elasticity as shown in part one before the treatment. After the treatment, it was also observed that some students had scientific understanding of the concepts under study while very few of them still maintained their prior conceptions. In view of the findings, conclusion and implication for teaching physics are made.

Keywords: understanding, instructional approaches, scientific conception, alternative conception, engage, explore, explain, extend, elaborate, evaluate

Introduction

The goals of science education should be to cultivate inquiring, knowing and rational mind for the conduct of good life and provide knowledge and understanding of complexity of the physical world (FRN, 2004). This means that teaching and learning of science should be geared towards making the learner acquire not just the facts but the understanding of the scientific concepts. The current reform in science education focus on the need for students of all grade levels to understand the scientific concepts in science of which physics is one, rather than knowing the breath of science facts (America Association for Advancement of Science (AAAS, 1993).

This reform calls for new instructional approaches that would make students understand the scientific concepts in physics. Therefore, to understand the scientific concepts in physics requires knowing the ideas, principles, phenomenon and the relationship among them. This also involves the knowledge of the ways to use ideas to explain and predict natural phenomena and ways to apply them to other events (Akerson, Flick and Lederman, 2000). America Association for Advancement of Science (AAAS, 1993) suggests that scientific understanding could be gained through inquiry instruction generated from students' experience. Also Akerson, Flick and Lederman (2000) said that in most science classroom it could be expected that students would have had experiences that help them develop stable and functional concepts in science about the world. These concepts, constructs or ideas would influence interpretation made in exploration in science instruction such as physics instruction.

Therefore, understanding the physics concepts presupposed that students are actively engaged with activities and development of ideas of physics in the learning process. Unfortunately, the traditional approaches often used by teachers do not offer the opportunity for student participation in the learning science. Traditional instructional approaches are those approaches in which teachers communicates their ideas to the learners by direct verbal discussion which students are passing only receiving information from the teacher. This approach does not encourage the students to engage in critical thinking but only lead them to rote learning with little or no transfer of knowledge. The students do not assimilate what they are taught because they are not actively involved in the learning process.

Novak (1988) observed that most teachers do not assess students understanding of concepts nor do they direct their teaching towards students' level of understanding. These kinds of physics instruction students receive do not seem to be effective in helping students change their misconceptions of physics concept. This implies that even when students were presented with the scientific knowledge of the physics concepts, they continue to keep their own ideas

in their minds. This situation shows that traditional teaching approaches could not sufficiently develop students scientific thinking and understanding of physics concepts.
Various instructional approaches have been developed to help address the need for eliciting and effectively addressing students understanding of concepts in physics. These approaches would help students assimilate and internalize concepts as well as meanings, principles and inter-relationship between different concepts. One such instructional approaches which has been developed to assess students' understanding of concepts in physics is the learning cycle (TLC). The learning cycle approach is an inquiry-based teaching approach which can be useful to teachers in designing curriculum materials and instructional strategies in science. It is student-centered with activities that provide a basis for observation, data collection, analysis of minds on activities, events and phenomena. The learning cycle was originally developed by Karplus (1963) and it has three distinct phases of instruction namely exploration, invention (concept introduction) and discovery (concept application) but Hanuiscind and Lee (2007) later expanded the model into five phases namely engage, explore, explain, elaborate and evaluate (5Es). Stayer and Shroyer (2002) noted that engage and evaluate stages were added to Karplus models to make a more complete cycle, while explore, explain and evaluate stages in Bybees model correspond to exploration, concept introduction and concept application in Karplus model respectively. For this study, the 5 Es were adopted for the instruction.
Components of the learning cycle model (5 Es). This learning cycle model is a five phase inquiry approach consisting of engage, explore, explain, extend/elaborate and evaluate. This is represented diagrammatically as

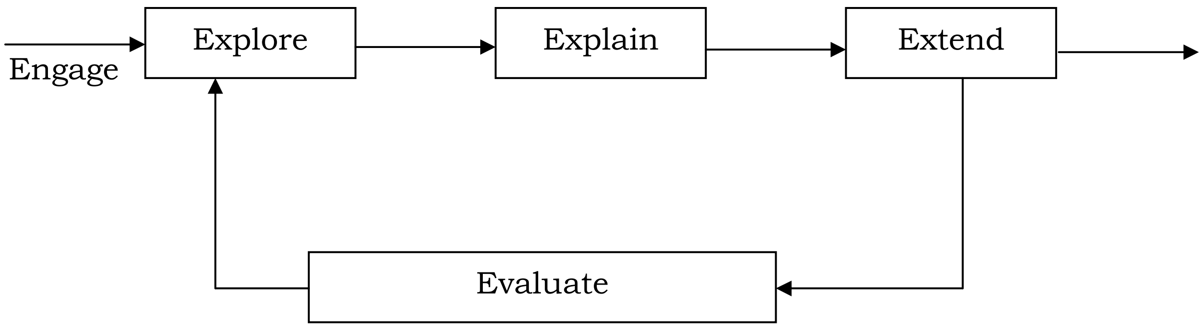

Figure 1: The Learning cycle model (5Es)

Engage: This is the component of the lesson during which the teacher tries to get the attention and interest of the students. The purpose of engagement is to:
- focus students' attention on the topic
- pre-assess the students' prior knowledge
- inform the students about the lesson's objectives
- remind students for what they already know that they will need to apply
- pose a problem for the students to explore in the next phase of the learning cycle.

Explore
The second component of the lesson and is often a laboratory activity that a team of students do. In this component, the students are at the centre of the action as they collect data to solve the problem. The teacher acts as a guide but permits students to explore and find answers to questions that have been raised. The students need to be active. The teacher often selects among the three strategies
- answering the student's question,
- pointing the students in a particular direction
- asking the right question to help the student decide how to proceed

Explain
In this component the teacher leads the students toward connecting the results of activity and/or topic to other topics already understood. Lecture/discussion method plays an active role in order to take advantage of the teacher's knowledge and experience. This is the stage when teachers share their insights with the students by asking probing questions that allow students to move toward personal understanding and scientifically accepted explanations. The teacher also introduces new vocabulary, phrases or sentences to label what the students have already identified. The emphasis here is to let the definitions and other concepts arise out of the experience rather than from the reading.

Extend/Elaborate

In this component, the students are engaged in applications of the knowledge gained. The creative ability of the student becomes important in this stage. The teacher gives students new information that extends what they have been learning in the earlier stages of the learning cycle. At this stage, the teacher also poses problems that students solve by applying what they have learned. The problems include both examples and non-examples.

Evaluate

This is not only an ongoing component of the lesson, but also an important component during which the students reflect on the topic studied. Evaluation could be formative as well as summative. Evaluation takes place at every phase of the learning cycle.

Evaluation role in engagement revolves round the pre-assessment. That is, finding out what the students already know about the topic by asking questions and making students respond orally or writing.

In exploration, evaluation focuses on process. That is, on the students' data collection, rather than the product of the students' data collection. Evaluation of explanation focuses on how well can students use the information they have collected and what they already know to come up with new ideas for instance, the teacher can ask students comprehension of new concepts.

Evaluation of elaboration may be equated to the test at the end of the lesson. Here the students are required to apply problems studied as part of elaboration and these application problems may be the test. In the best scenario, the evaluation will lead to a new topic, and a new engagement and as we continue and hence the learning cycle. However, some people say that this model is not appropriate for every science lesson, and every science lesson does not have the full complement of the five components, this model does give reasonable, realistic and usually reachable characteristics of a science lesson which necessitates its usage in this particular study.

The question investigated by this study was what are the students' understanding of concepts related to elasticity when taught with 5Es. In other words, the study was conducted to investigate the efficacy of learning cycle model (5Es) on the students understanding of elasticity by the secondary school students.

Method

Design

The design of the study was quasi-experimental with specific pretest posttest non-equivalent control group design.

Participants

Participants were Senior Secondary School students one (SS 1) who by virtue of their class were required to do physics. The subject were also required to do other science and mathematics subjects. The subjects were randomly selected from two secondary schools in Nsukka Urban. Nsukka is a town where University is situated. This university may have an influence on the behaviour of the students within the environment. The number of subjects was one hundred (100), 50 subjects from each school. The teachers teaching these students have degree in physics with teaching qualification. The students usually do practicals in addition to theories and physics is taught to them three times in a week.

These subjects have entered SS 1 where physics is taught as a separate subject. Any knowledge acquired about physics concepts was through integrated Science taught in Junior Secondary Schools one — three (JSS 1-3). However, the subjects have been exposed to some physics concepts in their first term of SS 1 since the study was carried out in the second term of their SS 1.

Instrument

The instrument used for both pretest and post test was physics concept test (PCT). This was developed and validated by the researchers. The test was used to determine the student's beliefs and misconceptions before exposure and subsequent knowledge and application of physics concepts and principles after exposing them to experimental treatment.

The PCT was in form of paper and pencil test which contained nine questions on concepts related to elasticity. The subjects were requested to respond to the questions according to their knowledge of the concepts/principles. The test was conceptional and application of mathematics was not required. The items were selected to target students' scientific knowledge of concepts related to elasticity.

Experimental Procedure

Two instructional approaches were employed for the study. The first approach was the use of 5Es while the second was the usual lecture method which was used as a base line. The two approaches were identical in terms of content, basic instructional objectives and mode of evaluation but differ in terms of instructional activities. The 5Es (learning cycle model) were used for experimental group while the lecture method was used for the control group which acted as reference point.

Before the treatment, the subjects in both groups were given physics concept test as pretest. After the pretest. Both experimental and control groups were given treatment using 5Es and lecture method respectively. Both groups were given treatment for one hour, three times in a week for four weeks. The experimental group was taught using 5Es learning model whose activities of instruction were divided into five steps as earlier described. At the end of the treatment, the subjects were given the posttest. The responses of the subjects were analyzed according to the subject's views about the concepts/principles. That is, analysis was carried out qualitatively.

Results

The students' responses were presented according to student's ways of looking at aspects of the concepts associated with elasticity. The subjects' conception of the concepts (in both experimental and control group) was compared in terms of how they expressed themselves in writing. The presentation was done in two parts. Part 1 is the student's conception before the instruction while Part 2 is after the instruction. The unedited statements written down were those that occur often among the students responses.

Part 1: Students' conceptions of concepts related to elasticity by each group before the treatment.

Q1 Explain what you understand by Elastic Material?

Students Response (SR)

Experimental:

- is a type of collision occur when the total energy of the causing bodies is conserved a material that conduct electricity, is a material that can regain its original shape when it is destroyed.
- are those materials than can expand when straighten and also those things that can melt when burning.
- are materials that you stretch they draw.
- is a material that can regain its original shape after being destroyed?

Control Group:

- are those materials that expand whenever it was stretched materials that doesn't increase when stretched. Materials that cannot conduct electricity.
- Is a process whereby an object change from its normal shape.
- a material when disturbed come back.
- a material that can extend when pulled.

Q2. What is an elastic limit?

SR:

Experimental

- a point that the materials reach after force been applied to it.
- A point when the distorting force cannot be stretched again
- when a material is not extended.
- are industries that produce elastic production.

Control

- A point that the material can no longer be stretched further.
- A point a material can no more be elastic and cannot stretch more.
- A region through which electrons flow or conductors.

Q3. Explain the elastic region of an elastic material.

SR:

Experimental

- A region of elasticity from point one to another
- "Region where elasticity occurs.

Control

- A region where the distorting force is experienced.
- A region which electric flows or conductors.

Q4. Explain the yield point of an elastic material.
SR:
Experimental
- The point in which the material has yielded all its elasticity.

Control
- The point where the material yield.

Q5. What is the breading point?
SR:
Experimental
- The point at which elasticity can no longer hold.

Control
- Elastic material reaches last point.

Q6. Define tensile stress
SR:
Experimental
- Point where is directly proportional to it area.

Control
- Ratio of extension to the load stress that it tensile.

Q7. Define Tensile Strain
SR:
Experimental
- Ratio of the extension to the load.

Control
- Ratio of the force to the area of the material.

Q8. Explain the term work done in stretching an elastic material.
SR:
Experimental
- Force applied in stretching an elastic material.
- The power you used to stretch the material.

Control
- Effort applied to stretch the material.
- Ability of compressing or stretching the material.

Q9. What is the elastic potential energy of an elastic material?
SR:
Experimental
- Energy stored
- Energy store and can be transformed from one form to another.
- Energy at rest.
- Point where the elastic material is free from distortion.

Control
- Energy possessed to a body.
- Ability of the material to be a place when stretched.
- Energy regained to make the material elastic.

The above responses showed that both groups have misconceptions about the elastic materials. Their views indicate that elastic materials are viewed from different perspectives.

Part 2

Students' conceptions of concepts related to elasticity after the treatment.
Q1: What do you understand by Elastic material?
SR:
Experimental
- Regains its original shape and size after the distorting force has been removed (c)

Control

- They are materials A material that have shape and size after distortion. (mc)

that return to their original shapes and sizes after the extending force has been removed.

- Materials that are used for the shape or size.

Q2: What is an elastic limit?

SR:

Experimental

- The limit beyond which the stretched wire does not return to their original length when the stretching force is removed.
- Region whereby the material reaches and cannot be expanded again.

sControl

- Limit of force beyond which the stretched wire cannot return to its normal shape and size after the applied force is removed.
- It is a material that regains its original shape and size at a particular time.

Q3: What is an elastic region of an elastic material?

SR:

Experimental

- The region which the stretched force stops which when stretched further more leads to yield point of the elastic material.
- The point where elasticity holds.

Control

- Ability to do work on the elastic material
- Is the length or the distance from the organ of the elastic to the elastic limit.
- Is the point if exceeded if Looke's law is not obeyed
- Region material experiences elasticity and can still regain its original shape and size.

Q4: What is the yield point of an elastic material Experimental Group

SR:

- Is the point beyond the elastic region where the material has yielded its elasticity and has become plastic. It cannot regain its original shape at this point.
- Region whereby the material reaches and cannot be expanded again.

Control

- Limit of force beyond which the stretched wire cannot return to its normal shape and size after the applied force is removed.
- It is the material that regains its original shape or size at a particular time.

Q5: What is a breaking point? Experimental Group

SR:

Experimental

- Point the material breaks or shape after attaining its maximum stretching
- Point the material cannot extend further and tends to break up if further extended.
- Point of maximum extension after which material breaks.

Control

- Point at which the material cannot withstand any more stretching.
- Point material cannot stand any increase in size.
- Point where the maximum extension is reached.

Q6: Define Tensile Stress

SR:

Experimental

- Ratio of force to area of the material
- Proportional to strain provided elastic limit is not exceeded.

Control

- Force applied at right angle to its cross — sectional area

- Ratio of extension to original length.

Q7: Define Tensile Strain
SR:
Experimental

- Ratio of extension to the original length

Control Group

- Point where extension is directly proportional to the length.

Q8: Explain the term work done in stretching an elastic material.
SR:
Experimental

- The product of force and the extension

Control Group

- Power that enables us to stretch the material.

Q9: What is the elastic potential energy of an elastic material?
SR:
Experimental

- Energy stored in a material after stretching

Control

- Energy used in stretching the elastic material.

Discussion

The study was to investigate the efficacy of 5 Es learning cycle model on students understanding of the concepts of elasticity. Results from this study shows that the implementation of the learning cycle model enhances student's understanding of key concepts and concepts involved in elasticity.

sPossible reasons for this observation may be attributed to value associated with alternative ways of acquiring knowledge in science and confirmation value of hand — on activities which are characteristics of learning model (Lawson, 2001).

During the learning cycle, students learned through their own actions and reactions by involving hand — on — activities. They explored new materials and phenomena that raise questions and encourage them to seek answers.

Students' exploration involved in collecting and analyzing data allowed them testing the alternative conceptions. Students in the experimental group were also involved in activities that help them to examine the adequacy of their prior conceptions and required them to argue about and test their conceptions. This leads to disequilibrium when predictions based on their prior beliefs are contradicted and provides the opportunity to construct more appropriate concepts. Thus, learning cycle model requires a teaching strategy in which students will have more opportunity to identify and express their pre-conceptions, examine the utility of the concepts and apply the new concepts and ideas in context familiar to them. However, in the traditional group, the students focused on concepts related to the subject that require less conceptual restructuring.

The finding of this study regarding better performance of students in learning cycle group is consistent with the view claiming that correct use of the learning cycle accomplishes effective learning of science concepts (Cavello, 1995; Lawson et al; 2000; Lawson, 2001). According to Lawson, (2001), learning new concepts is not purely abstractive process. Rather, concept acquisition depends upon one's ability to generate and test ideas or hypotheses and reject those that lead to contradictions. This concept learning can be characterized as constructive while new conceptual knowledge depends upon skill in testing ideas, concept construction becomes easier. The data indicated that learning cycle model did not help students in constructing a scientific mental model of some concepts in elasticity.

Further research need to be conducted in identifying the shortcomings of the learning cycle model. Results of this study support the findings of previous research which indicated that some concepts and aspects of the elasticity play a more central role in students' mental models. Consequently, instruction may affect some concepts and aspects of elasticity to different degree. For example, it is indicated that after instruction, students can easily change their views about some aspect of elasticity than about others. Some aspects of students' mental models of elasticity are more resistant to change, such as those involving the concepts of energy and work done. The problem with this is lack of clear differentiation between energy and work done while others mentioned that the problem is with lack of the robust models of understanding microscopic process leading to the macroscopic phenomena observed.

In this study, the effect of learning cycle model was found to be significant on teaching most of the concepts and the aspects involved in elasticity but not on teaching work and energy. Recognizing risk inherent in interpretation of finding from this study, it is suggested that physics teachers who teach elasticity in mechanics for secondary school students should consider the effectiveness of including inquiry based activities into their instructions. Inquiry based activities may be of particular value to the prospective science teacher. Efforts to increase future physics teachers' attitude toward using inquiry approaches are of particular importance in that they may result in effective physics instruction, thus affecting large numbers of future physics learners.

Implications for the Study and Conclusion

This study has attempted to determine, the students understanding of concepts in elasticity. This was done through collection of students' self explanation of the concepts before and after treatment using physics conceptual test. Results of the study suggest that the students possess alternative conceptions of elasticity concepts. Some of the conceptions are dropped after the treatment by the students in both groups (experimental and control) while some students especially in the control group still have difficulty in changing their alternative conceptions to scientific conceptions.

The implication of this is that the physics teachers may have to confront some of the students' alternative ideas in elasticity which is not easy to change. Another implication of this study is that students need to be aware of these conceptions and confront them through the use of 5Es that would allow students active participation. When teaching about concepts in elasticity it is very important to provide students with enough time and opportunity to construct, at their own pace, a meaningful conceptual model of properties of elasticity that will be in accordance with scientific conceptions.

The study of student's alternative conceptions in physics is engaged to assist teachers become aware of the presence of alternative conceptions among the students in the classroom and realized the need to adopt inquiry - based approach of teaching physics to facilitate conceptual change. Experimental group were able to give the actual explanation of the concept while some in the control group gave the actual meaning of work while the remaining regarded work done as the power that enables the material to be stretched. In the cases of elastic potential energy, the experimental group regarded it as energy at rest or energy transformed from one form to another while those in control group regarded it as energy possessed by a body or ability of a material to be at a piece when stretched. Their responses stemmed from the fact that potential energy is classically defined as energy possessed by a body at rest. They failed to differentiate potential energy in a mechanical state from elastic potential energy which is energy stored in a material as a consequence of its stretched or compressed state.

However, after the treatment, those in the experimental group were able to show that elastic potential energy is the energy stored in a material after stretching while those in the control group still regarded elastic potential energy as energy used in stretching the elastic material as shown in their responses written in part 2.

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